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RADIO SHACK TRS-80 POCKET COMPUTER SOLUTIONS TO COMPOSITE MATER--ETC(U)
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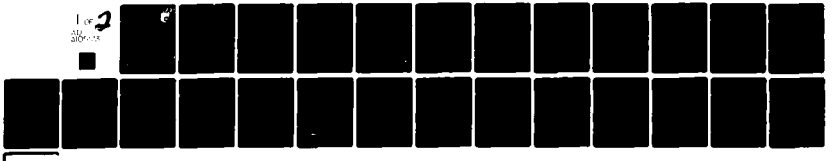

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RADIO SHACK TRS-80 POCKET COMPUTER SOLUTIONS TO COMPOSITE MATERIALS FORMULAS

WON J. PARK

UNIVERSAL ENERGY SYSTEMS, INC.
DAYTON, OHIO 45432

AUGUST 1981

FINAL REPORT FOR PERIOD JANUARY 1981-MAY 1981

Approved for Public Release; Distribution Unlimited

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This technical report has been reviewed and is approved for publication.

S. W. TSAI, Project Engineer & Chief
Mechanics and Surface Interactions Branch
Nonmetallic Materials Division

FOR THE COMMANDER

F. D. CHERRY, Chief
Nonmetallic Materials Division

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BASIC Programming
Composite Materials
Properties of Undirectional and Laminated Composite
In-Plane and Flexural Stiffness and Strength

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This volume contains the description and instructions of the use of Radio Shack TRS-80 Pocket Computer for the key calculations of the stiffness and strength of symmetric laminated composites. The magnetic cassette tapes contain the required programming in the language of BASIC. With the aid of tape recorder for loading the program into TRS-80, instant calculation can be made for practical use. The formulas and equation numbers used in the programming have been derived in a book entitled, Introduction to Composite

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20. ABSTRACT

Materials, coauthored by S. W. Tsai and H. T. Hahn, published by Technomic Publishing Company, Westport, CT, July 1980.

FOREWORD

This report was prepared in the Mechanics and Surface Interactions Branch (AFWAL/MLBM), Nonmetallic Materials Division, Materials Laboratory, Air Force Wright Aeronautical Laboratories, Wright-Patterson AFB, Ohio. The work was performed under Contract F33615-79-C-5125, Project UES 117.

The time period covered by this report was from January to May 1981. Dr. Won J. Park was a senior scientist from Universal Energy Systems, Inc. and Professor of Mathematics and Statistics at Wright State University.

The equations and table numbers which appear in the flow charts are the same as in Introduction to Composite Materials, co-authored by S. W. Tsai and H. T. Hahn, published by Technomic Publishing Company, Westport, CT, in July 1980.

Those who want to receive the programmed magnetic cassette tape should contact Dr. Stephen W. Tsai, AFWAL/MLBM, Wright-Patterson AFB, Ohio 45433, Tel: 513-255-3068.

TABLE OF CONTENTS

SECTION I

USER GENERAL INSTRUCTIONS

(1) The program language for TRS-80 Pocket Computer is BASIC and the elementary part of BASIC program instructions are given in the Radio Shack instruction manual - Catalog Number 26-3501, which usually comes with TRS-80 Pocket Computer.

(2) It is noted that the instructions for loading and recording of the program using the magnetic cassette tape can be found in page 74-76 and page 90-94 in the instruction manual.

(3) Two programs, Program 1 and Program 2, are recorded in our magnetic cassette tape with the following characteristics.

Name*	File Name	Tape Counter † reading
Program 1	"PGM-1"	0-47
Program 2	"PGM-2"	50-88

* See the Table of Contents
† Tape counter reading in the tape recorder.

(4) Composite Material Constants listed in (a) and (b) below are inputed in the programs. For a different material constants it is needed to change the input directly on the programs.

(a) Program Step 20 in Program 1.

$$**A = 181E9 \leftrightarrow E_x$$
$$S = 10.3E9 \leftrightarrow E_y$$
$$D = 280E\text{-}3 \leftrightarrow \nu_x$$
$$F = 7.17E9 \leftrightarrow E_s$$
$$H = .125E\text{-}3 \leftrightarrow h_o$$

**This material constants are for the composite material T300/5208.

(b) Program Step 300 in Program 2.

Q = 1.5E9 $\leftrightarrow$ X

W = 1.5E9 $\leftrightarrow$ X'

E = 40E6 $\leftrightarrow$ Y

R = 246E6 $\leftrightarrow$ Y'

T = 68E6 $\leftrightarrow$ S

(5) Once the computation of program 1 was completed and when the loading of program 2 is executed in TRS-80 pocket computer, the data stored in the fixed memories (A - Z memory) will be erased and the data stored only in the flexible memories (A(·) memory) will be remaining in the computer.

SECTION II

CONTENTS OF PROGRAMS

Each of Program 1 and Program 2 can be divided into 3 sub-programs, named "A", "B" and "C". These sub-programs perform a specific composite material computation as follows:

(a) Program 1

"A": Properties of Unidirectional Composites

"B": In-Plane Stiffness of Symmetric Laminates

"C": Flexural Rigidity of Symmetric Sandwich Plates

(b) Program 2

"A": Properties of Unidirectional Composite

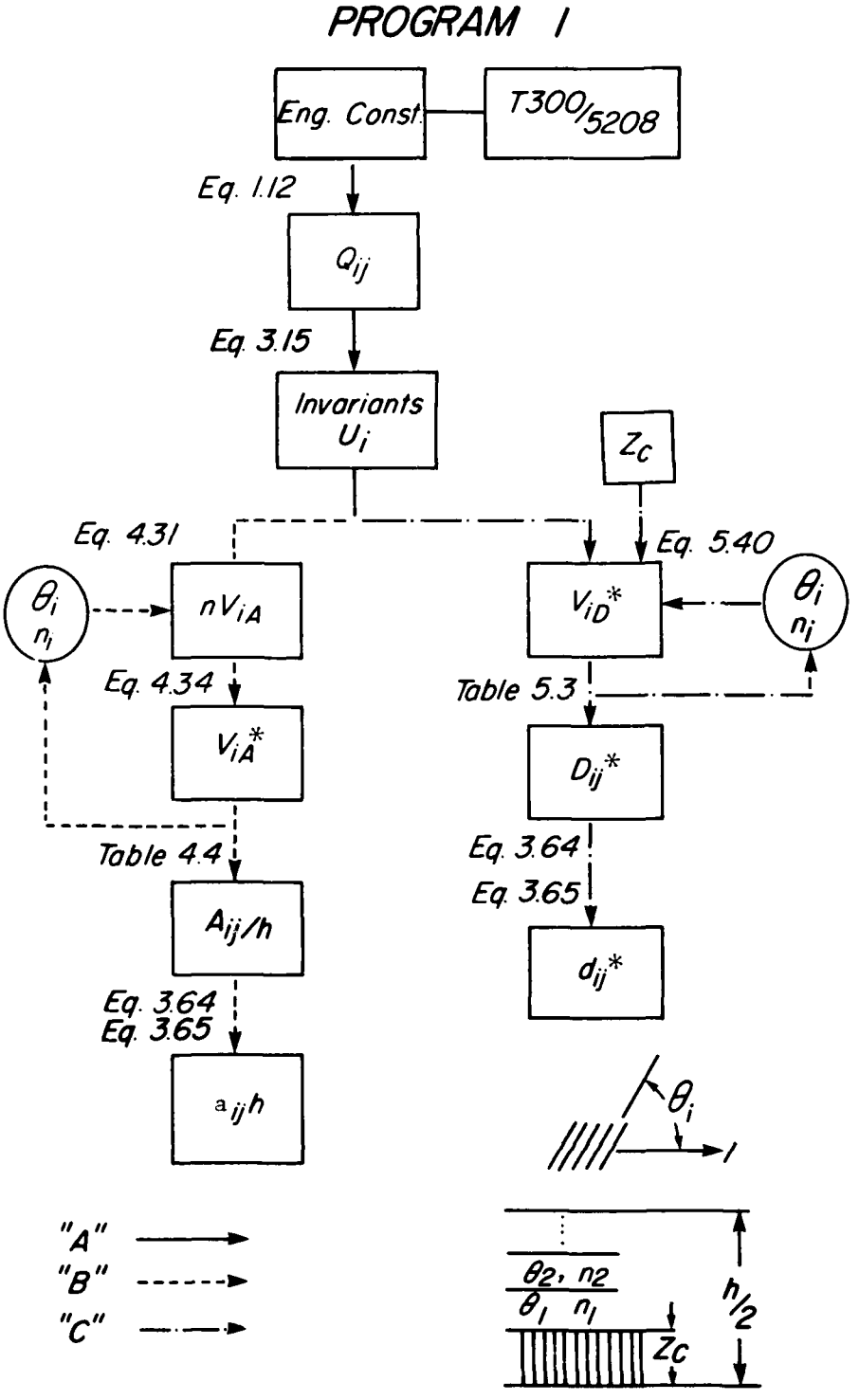
"B": In-Plane Strength of Symmetric Laminates

"C": Flexural Strength of Symmetric Sandwich Plates

It is also noted that the sub-program "A" can be utilized by pressing the keys [SHFT] [A], "B" by [SHFT] [B] and "C" by [SHFT] [C] (see the operations in page 6 and page 13).

SECTION III

PROGRAM 1. STIFFNESS



1. User Instructions for Program 1

a. Loading Program 1.

(a) Connect the cassette interface to the tape recorder and attach TRS-80 computer to the cassette interface. The type counter of the tape recorder should be set at zero.

(b) Turn on TRS-80 (press [ON]) and set DEG and PRO modes.

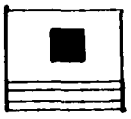
(c) Press play key PLAY of the tape recorder.

(d)

Operation (press)	Display
[C] [L] [O] [A] [D] [SHFT] [W] [P] [G] [M] [-] [1] [SHFT] [W]	CLOAD "PGM-1"
[ENTER]	

Note that during the execution of loading, the mode changes from "PRO" to "RUN" and back to "PRO" when the execution is completed.

(e) When the loading of Program 1 is completed, the tape recorder stops automatically, but it is needed to press Stop/Eject key, STOP/EJECT , in the tape recorder.



b. Operation of Program 1.

(a) Press [↧] or [↥] several times to check that the program is loaded.

(b) Press [MODE] twice to change the mode from PRO to DEF.

(c) Perform the following operations - Sample problems.

Display	Operation	Remarks
	SHFT A	*Beep 1
	SHFT B	
ANGLE =	0 ENTER	$[\ 0^{o}_{4}\ /\ 90^{o}_{4}\ ]_{s}$
PLY NO. =	4 ENTER	
ANGLE =	9 0 ENTER	
PLY NO. =	4 ENTER	See **
ANGLE =	R ENTER	R indicates no more angle input. Beep 2
	SHFT C	
CORE PLY NO. =	0 ENTER	0^{o}_{4} / 90^{o}_{4}
ANGLE =	9 0 ENTER	
PLY NO.	4 ENTER	
ANGLE =	0 ENTER	
PLY NO. =	4 ENTER	See **
ANGLE =	R ENTER	Beep 3

*Beep sounds indicate the completion of computations.

** should continue to input the angle and ply no. if there is additional ply layers.

Program 1. Memory Storage

Key-Board Memories

Key	A	B	C	Key	A	B	C	Key	A	B	C
Q		V_{1A}^*	V_{1D}^*	A	E_X,$^+\bar{U}_6$			Z		A_{11}/h	$12D_{11}/h^3$
W		V_{2A}^*	V_{2D}^*	S	E_Y, $\bar{U}_5$			X		A_{22}/h	$12D_{22}/h^3$
E		V_{3A}^*	V_{3D}^*	D	ν_X, $\bar{U}_2$			C		A_{12}/h	$12D_{12}/h^3$
R		*	*	F	E_S, $\bar{U}_3$			V		A_{66}/h	$12D_{66}/h^3$
T		V_{4A}^*	V_{4D}^*	G		A_{26}/h	$12D_{26}/h^3$	B		A_{16}/h	$12D_{16}/h^3$
Y		$\det(A_{ij})$	$\det(D_{ij})$	H	h_o			N		n_i	n_i
U		*	*	J				M	m		
I			*	K			h*				
O		θ_i	θ_i	L			Core ply no.				
P		sum of n_i	sum of n_i								

A(·) - Memories

A(·)	A	B	C	A(·)	A	B	C	A(·)	A	B	C
27	Q_{xx}			36		*	*	45			d_{11}^*
28	Q_{yy}			37		*	*	46			d_{22}^*
29	Q_{xy}			38		*	*	47			d_{12}^*
30	Q_{ss}			39		$a_{11}h$		48			d_{66}^*
31		V_{1A}^*		40		$a_{22}h$		49			d_{16}^*
32		V_{3A}^*		41		$a_{12}h$		50			d_{26}^*
33		*	*	42		$a_{66}h$		51			h*
34		*	*	43		$a_{16}h$		52			
35		*	*	44		$a_{26}h$		53			

*denotes control variable

$\bar{U}_6 = \frac{1}{2}(\bar{U}_1 + \bar{U}_4)$, $\bar{U}_5 = \frac{1}{2}(\bar{U}_1 - \bar{U}_4)$

Program 1. Computation Problem After "B"

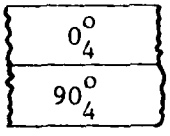
$[\ 0_4^\circ\ /\ 90_4^\circ\ ]_s$ Key-Board Memories

Key		Key		Key	
Q	0	A	4.94877866E10	Z	9.607864876E10
W	1	S	2.688043108E10	X	9.607864876E10
E	0	D	8.573249004E10	C	289692440
R		F	1.971043108E10	V	7170000000
T	0	G	0	B	0
Y		H	.000125	N	
U		J		M	1.00448143
I		K			
O		L			
P					

A(•)-Memories

A(·)		A(·)		A(·)	
27	1.818111383E11	36		45	
28	1.034615873E10	37		46	
29	2896924444	38		47	
30	7170000000	39	1.041761056E-11	48	
31	0	40	1.041761056E-11	49	
32	0	41	-3.141075674E-13	50	
33		42	1.39470014E-10	51	
34		43	0	52	
35		44	0	53	

Program 1. Computation Problem
After "C"



Key-Board Memories

Key		Key		Key	
Q	.75	A	4.94877866E10	Z	1.603780163E11
W	1	S	2.688043108E10	X	3.177928123E10
E	0	D	8.573249004E10	C	2896924440
R		F	1.971043108E10	V	7170000000
T	0	G	0	B	0
Y		H	.000125	N	
U		J		M	
I		K	6.66666666E-10		
O		L	0		
P					

A(•)-Memories

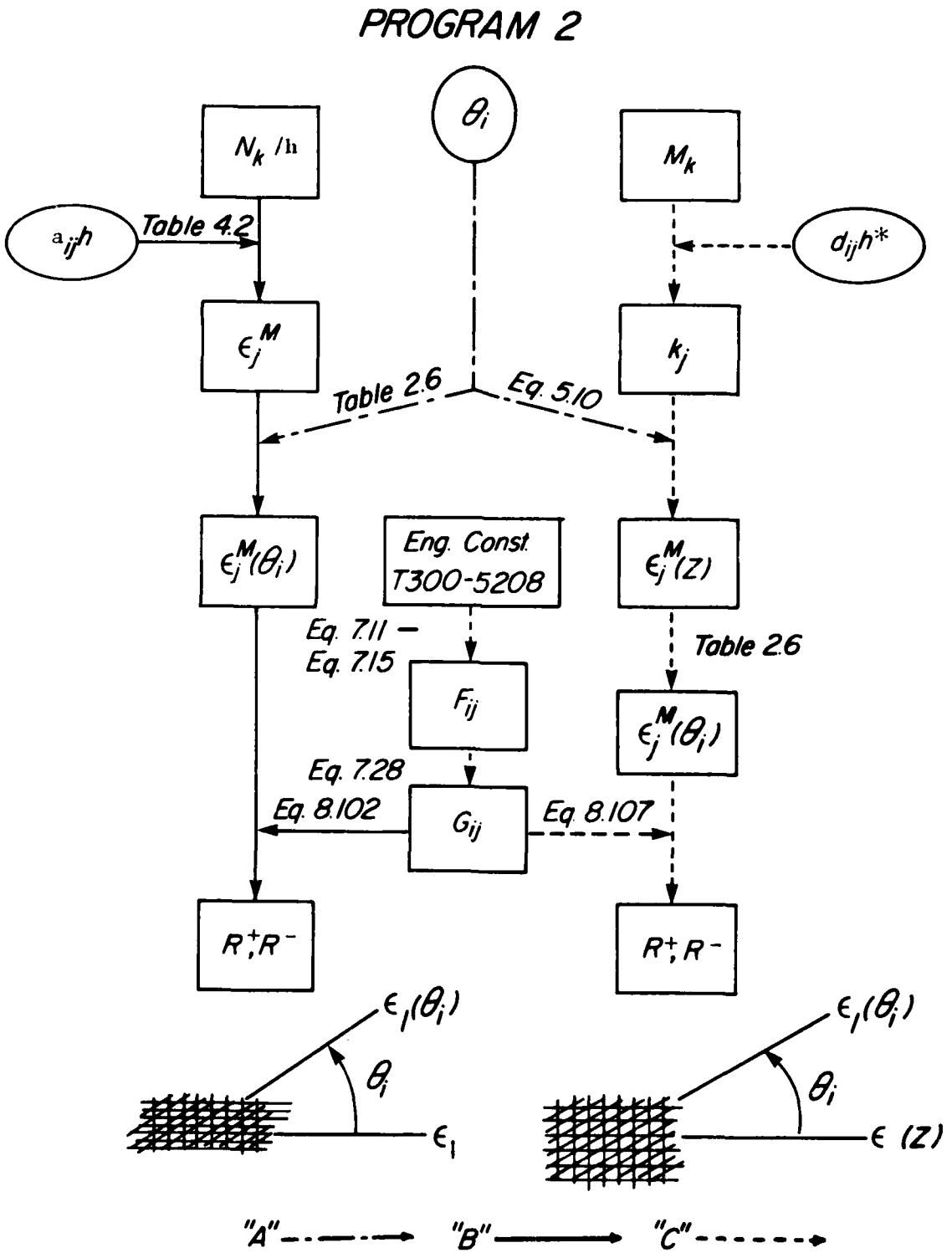
A(·)		A(·)		A(·)	
27	1.818111388E11	36		45	6.245552406E-12
28	1.034615873E10	37		46	3.15894148E-11
29	2896924444	38		47	-5.693298497E-13
30	7170000000	39	1.041761056E-11	48	1.394700139E-10
31	0	40	1.041761056E-11	49	0
32	0	41	-3.41075694E-13	50	0
33		42	1.39470014E-10	51	
34		43	0	52	
35		44	0	53	

```
1       "PGM-1"
10      "A":CLEAR
20      A=181E9, S=10.3E9, D=280E-3, F=7.17E9, H=.125E-3
30      M=1/(1-D*D*S/A)
40      A(27)=M*A, A(28)=M*S, A(29)=M*D*S, A(30)=F
50      A=1/8*(2A(27)+2A(28)+4A(29)), S=1/8*(A(27)+A(28)-2A(29)+4A(30))
60      D=1/2*(A(27)-A(28)), F=1/8*(A(27)+A(28)-2A(29)-4A(30)) : BEEP 1
70      END
80      "B"
85      PAUSE "IN-PLANE STFFNSS"
90      P=0, Q=0, W=0, E=0, T=0, R=500, U=1
110     INPUT "ANGLE="; O                (here O is the capital letter O
120     IF O<=180 GOTO 140                and not the number zero)
130     IF O>180 GOTO 180
140     INPUT "PLY NO.="; N
150     P=P+N
160     Q=Q+N*COS(2O), W=W+N*COS(4O), E=E+N*SIN(2O), T=T+N*SIN(4O)
170     GOTO 110
180     Q=Q/P, W=W/P, E=E/P, T=T/P
190     A(31)=Q, A(32)=E
200     GOTO 500
210     A(39)=A(33), A(40)=A(34), A(41)=A(35), A(42)=A(36), A(43)=A(37),
        A(44)=A(38)
220     BEEP 2
230     END
240     "C"
245     PAUSE "FLEX. RIGIDITY"
250     Q=0, W=0, E=0, T=0, R=500, U=2, P=0
260     INPUT "CORE PLY NO.="; L
270     P=L
280     INPUT "ANGLE="; O
290     IF O<=180 GOTO 310
300     IF O>180 GOTO 360
310     INPUT "PLY NO.="; N
```

```
320     P=P+N
330     Q=Q+(P^3-(P-N)^3)*COS(2Q), W=W+(P^3-(P-N)^3)*COS(4Q)
340     E=E+(P^3-(P-N)^3)*SIN(2Q), T=T+(P^3-(P-N)^3)*SIN(4Q)
350     GOTO 280
360     I=P^3-L^3
370     Q=Q/I, W=W/I, E=E/I, T=T/I
380     GOTO 500
385     K=3/12*I*H^3
390     A(45)=A(33), A(46)=A(34),A(47)=A(35), A(48)=A(36), A(49)=A(37),
        A(50)=A(38)
400     A(51)=K : BEEP 3
410     END
500     Z=A+S+Q*D+W*F, X=A+S-Q*D+W*F, C=A-S-W*F, V=S-W*F,
        B=E*D/2+T*F, G=E*D/2-T*F
510     Y=Z*X*V+2C*G*B-X*B*B-V*C*C-Z*G*G
520     A(33)=(X*V-G*G)/Y, A(34)=(Z*V-B*B)/Y, A(35)=(B*G-C*V)/Y
530     A(36)=(Z*X-C*C)/Y, A(37)=(C*G-X*B)/Y, A(38)=(C*B-Z*G)/Y
540     IF U=1 GOTO 210
550     IF U=2 GOTO 385
```

SECTION IV

PROGRAM 2. STRENGTH



1. User Instructions for Program 2

a. Loading Program 2.

Procedure (a), (b), (c) and (e) are same as in Program 1.

(d)

Operation (press)	Display
[C] [L] [O] [A] [D] [SHFT] [W] [P] [G] [M] [-] [2] [SHFT] [W]	CLOAD "PGM-2"
[ENTER]	

b. Operation of Program 2.

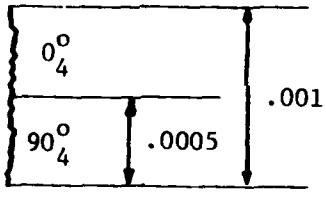
Steps (a) and (b) are same as in Program 1

(c) Perform the following operations - Sample problems.

Display	Operation	Remarks
	[SHFT] [A]	
ANGLE =	[0] [ENTER]	Beep 1
	[SHFT] [B]	
N1-M/H =	[1] [ENTER]	
N2-M/H =	[0] [ENTER]	
N6-M/H =	[0] [ENTER]	Beep 2
R+ = 6.81882008E8		
	[ENTER]	
R- = 1.10770531E09		

Display	Operation	Remarks
	SHFT C	
M1 =	1 ENTER	
M2 =	0 ENTER	
M6 =	0 ENTER	
Z =	· 0 0 1 ENTER	Beep 2
R+ = 7.91979781E02		
	ENTER	
R- = 1.13704881E03		
	SHFT A	
ANGLE =	9 0 ENTER	Beep 1
	SHFT B	
N1-M/H	1 ENTER	
N2-M/H	0 ENTER	
N6-M/H	0 ENTER	
R+ = 3.73395515E08		
	ENTER	
R- = 2.26881887E09		
	SHFT C	

Display	Operation	Remarks
M1 =	[1] [ENTER]	
M2 =	[0] [ENTER]	
M6 =	[0] [ENTER]	
Z =	[.] [5] [Exp] [-] [3] [ENTER]	
R+ = 8.35694320E02		
	[ENTER]	
R- = 4.80924818E03		



Program 2. Memory Storage

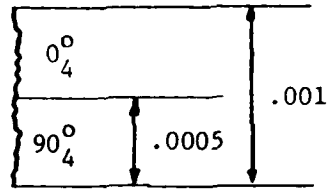
Key-Board Memories

Key	A	B	C	Key	A	B	C	Key	A	B	C
Q		X a	X	A		G_{xx}	G_{xx}	Z		ε_1^M	k_1
W		X' b	X'	S		G_{yy}	G_{yy}	X		ε_2^M	k_2
E		Y	Y	D		G_{xy}	G_{xy}	C		ε_3^M	k_3
R		Y'	Y'	F		G_{ss}	G_{ss}	V		P, R+	P, R+
T		S	S	G		G_x	G_x	B		q, R-	q, R-
Y		F_{xx}	F_{xx}, z	H		G_y	G_y	N		*	*
U		F_{yy}	F_{yy}	J		N_1^M/h	M_1	M	θ_i		
I		F_x	F_x	K		N_2^M/h	M_2				
O		F_y	F_y	L		N_6^M/h	M_6				
P		$F_{xy}^*=-\frac{1}{2}$	F_{xy}^*								

A(•)-Memories

A(·)	A	B	C	A(·)	A	B	C	A(·)	A	B	C
27				36				45			d_{11}^*
28				37				46			d_{22}^*
29				38				47			d_{12}^*
30				39		a_{11}^*		48			d_{66}^*
31				40		a_{22}^*		49			d_{16}^*
32				41		a_{12}^*		50			d_{26}^*
33		$\varepsilon_1^M(\theta_i)$	$\varepsilon_1^M(\theta_i)$	42		a_{66}^*		51			h*
34		$\varepsilon_2^M(\theta_i)$	$\varepsilon_2^M(\theta_i)$	43		a_{16}^*		52			
35		$\varepsilon_6^M(\theta_i)$	$\varepsilon_6^M(\theta_i)$	44		a_{26}^*		53			

Program 2. Computation Problem
"A", "B" and "C"



Key-Board Memories

Key		Key		Key	
Q		A	12004.38352	Z	
W		S	10680.65201	X	
E		D	-3069.103205	C	
R		F	11117.84169	V	
T		G	60.64699548	B	
Y		H	216.5964124	N	
U		J		M	0 or 90
I		K			
O		L			
P					

A(•)-Memories

A(·)		A(·)		A(·)	
27		36		45	6.245552406E-12
28		37		46	3.151894148E-11
29		38		47	-5.693298497E-13
30		39	1.041761056E-11	48	1.394700139E-10
31		40	1.041761056E-11	49	
32		41	-3.141075674E-13	50	
33		42	1.39470014E-10	51	
34		43		52	
35		44		53	

```
  1     "PGM-2"
 10     "A"
 20     PAUSE "INPUT ANGLE"
 30     INPUT "ANGLE="; M
 40     BEEP 1
 50     END
 60     "B"
 70     PAUSE "IN-PLANE STRENGTH"
 80     INPUT "NI-M/H="; J
 81     INPUT "N2-M/H="; K
 82     INPUT "N6-M/H="; L
 85     N=1
 90     Z=A(39)*J + A(41)*K + A(43)*L
 95     X=A(41)*J + A(40)*K + A(44)*L
100     C=A(43)*J + A(44)*K + A(42)*L
110     V=(Z+X)/2, B=(Z-X)/2
120     A(33)=V+B*COS(-2M) + C/2*SIN(-2M)
130     A(34)=V-B*COS(-2M) - C/2*SIN(-2M)
140     A(35)=-2B*SIN(-2M) + C*COS(-2M)
150     IF N=1 GOTO 290
160     IF N=2 GOTO 280
170     END
190     "C"
200     PAUSE "FLEX. STRENGTH"
201     INPUT "M1="; J
202     INPUT "M2="; K
203     INPUT "M6="; L
210     INPUT "Z="; Y
220     N=2
230     Z=A(45)*J + A(47)*K + A(49)*L
240     X=A(47)*J + A(46)*K + A(50)*L
250     C=A(49)*J + A(50)*K + A(48)*L
260     Z=Z/A(51), X=X/A(51), C=C/A(51)
270     GOTO 110
```

```
280     A(33)=A(33)*Y, A(34)=A(34)*Y, A(35)=A(35)*Y
290     P=-1/2
300     Q=1.5E9, W=1.5E9, E=40E6, R=246E6, T=68E6
310     Y=1/Q/W, U=1/E/R, I=1/Q-1/W, O=1/E-1/R
320     P=P*√(Y*U)
330     A=Y*A(27)^2 + 2P*A(27)*A(29) + U*A(29)^2
340     S=Y*A(29)^2 + 2P*A(29)*A(28) + U*A(28)^2
350     D=Y*A(27)*A(29) + P*(A(27)*A(28)+A(29)^2) + U*A(29)*A(28)
360     F=(A(30)/T)^2, G=I*A(27) + O*A(29), H=I*A(29) + O*A(28)
370     Q=A*A(33)*A(33) + 2D*A(33)*A(34) + S*A(34)*A(34) + F*A(35)*A(35)
380     W=G*A(33) + H*A(34)
390     V=-W/2/Q + √(W*W/4/Q/Q + 1/Q)
400     B=W/2/Q + √(W*W/4/Q/Q + 1/Q) : BEEP 2
405     USING "###. ########^"
410     PRINT "R+="; V
415     USING "###. ########^"
420     PRINT "R-="; B
430     END
```

SECTION V

CONCLUSIONS

The description and instruction of the use of Radio Shack TRS-80 pocket computer for the key calculations of the stiffness and strength of symmetric laminated composites are presented in this paper. With the computer packages that were programmed, instant calculations can be made for practical use.

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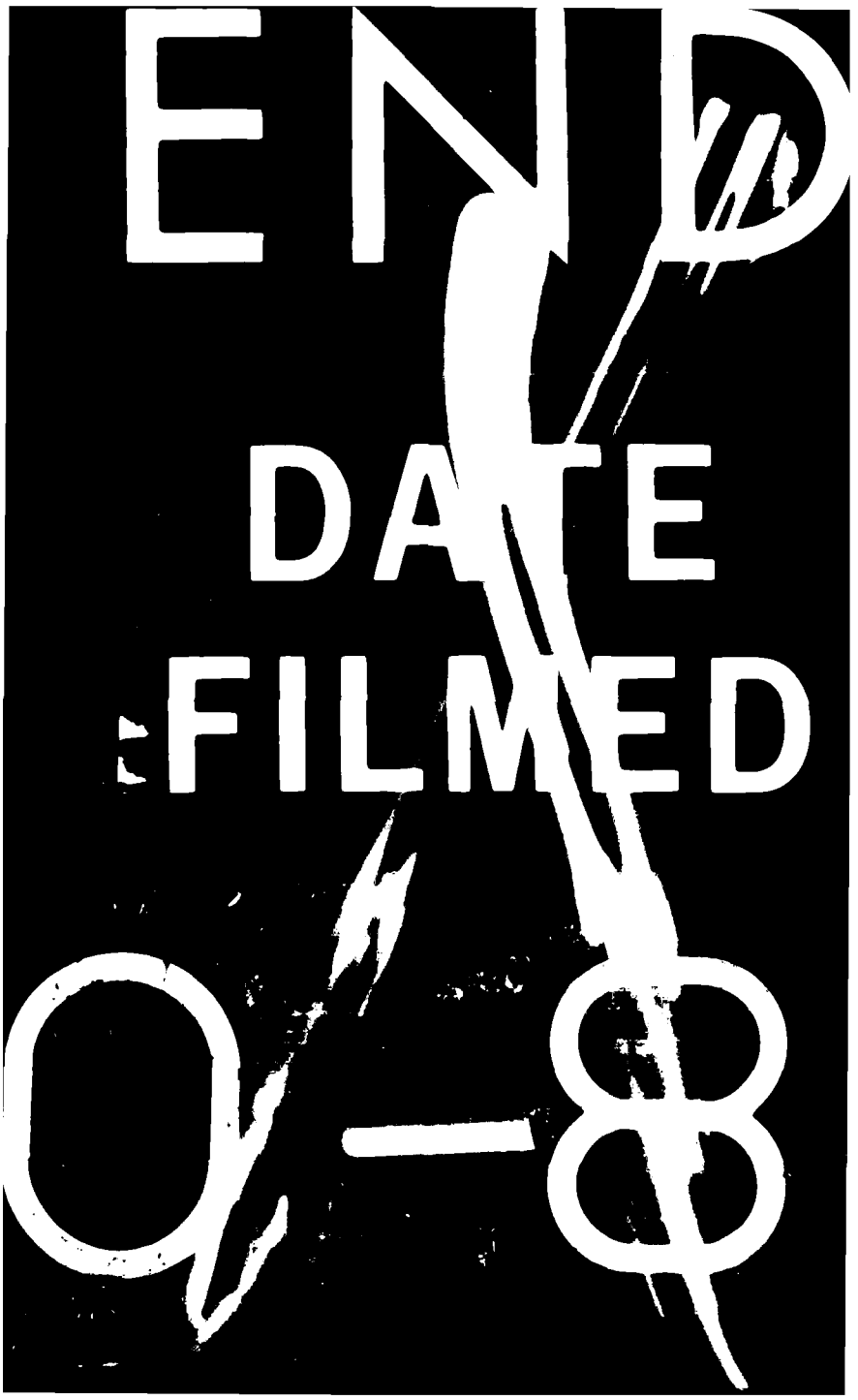
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AD-A105 173 RADIO SHACK TRS-80 POCKET COMPUTER SOLUTIONS TO COMPOSITE MATERIALS FORMULAS(U) UNIVERSAL ENERGY SYSTEMS INC DAYTON OH W J PARK AUG 81 AFWAL-TR-81-4074

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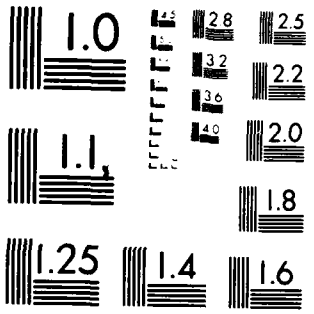


SUPPLEMENTARY

INFORMATION

DEPARTMENT OF THE AIR FORCE
AIR FORCE WRIGHT AERONAUTICAL LABORATORIES (AFSC)
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

Aug 83

REPLY TO ATTN OF: MLBM (W. J. Park, 513-255-6685)

SUBJECT: Correction of an Error in AFWAL-TR-81-4074

TO:

AD-A105173

1. We are trying to contact anyone who might have received our technical report, AFWAL-TR-81-4074, "Radio Shack TRS-80 Pocket Computer Solutions to Composite Materials Formulas", because we have found a typo error in the report.

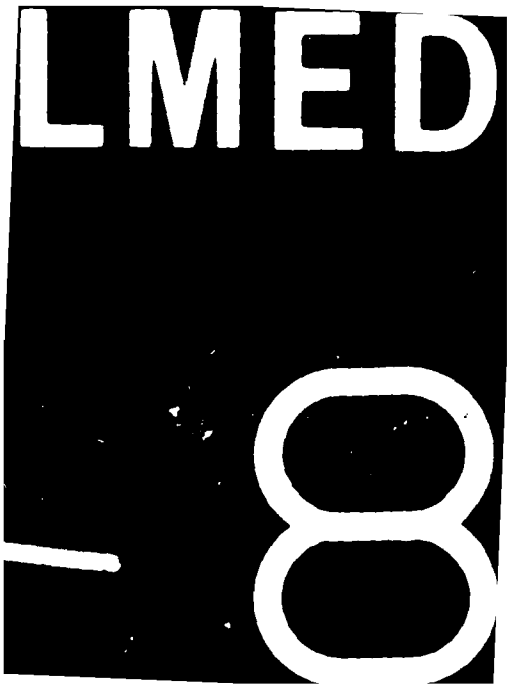
2. Please make the following correction in the program:

Page 11, Line 8 from the top,

385 K = $\frac{8}{12}$ * I * H 3, i.e. $\frac{3}{12}$ should be $\frac{8}{12}$ in the program step 385.

Won J. Park

WON J. PARK
Visiting Scientist
Mechanics and Surface Interactions Branch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